Korea Meteorological Administration

The 9th CCMC Workshop

Plans for Implementation and Evaluation of KSEM L2 products

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Korea Meteorological Administration

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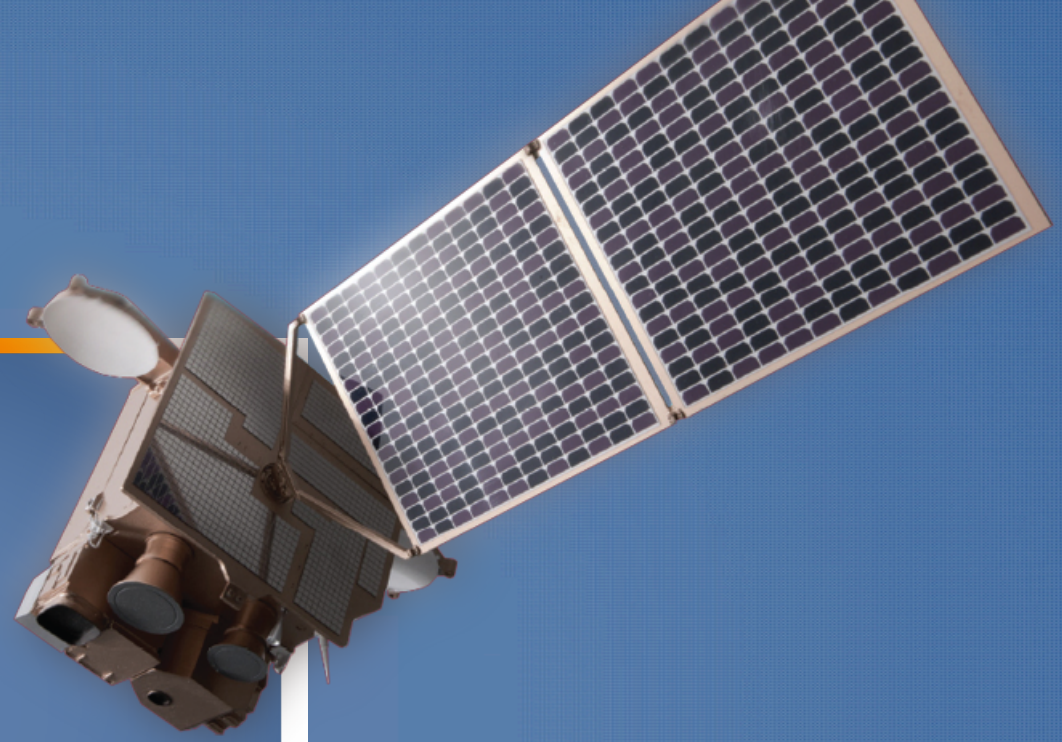

I GK2A, *the Next Gen. Geo-Meteo Satellite*

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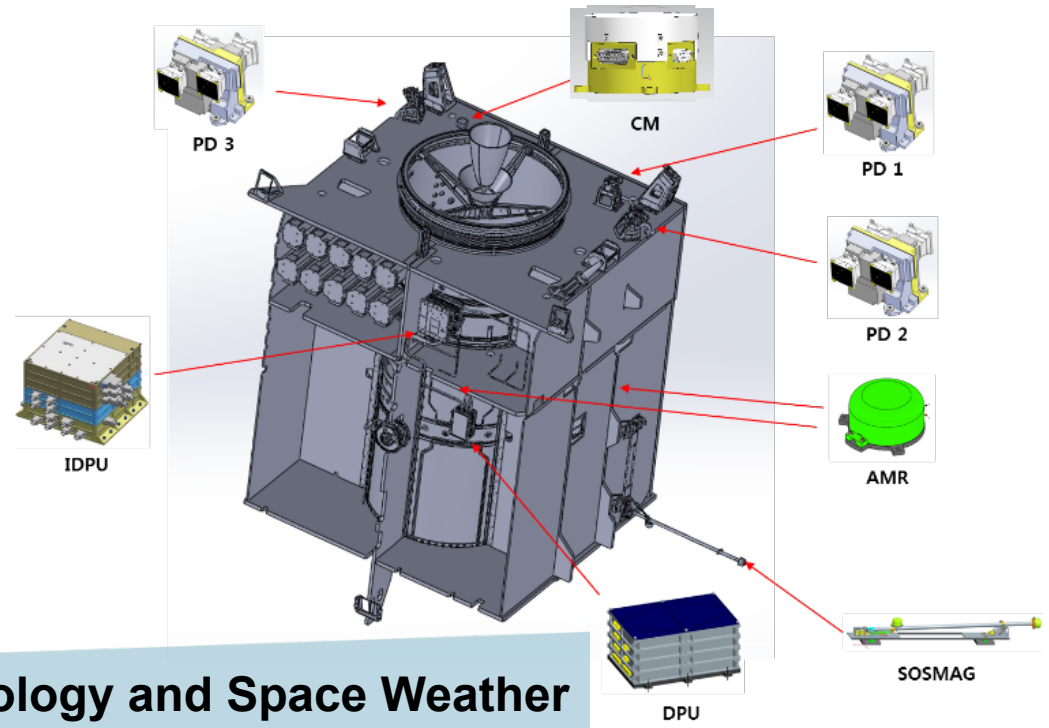
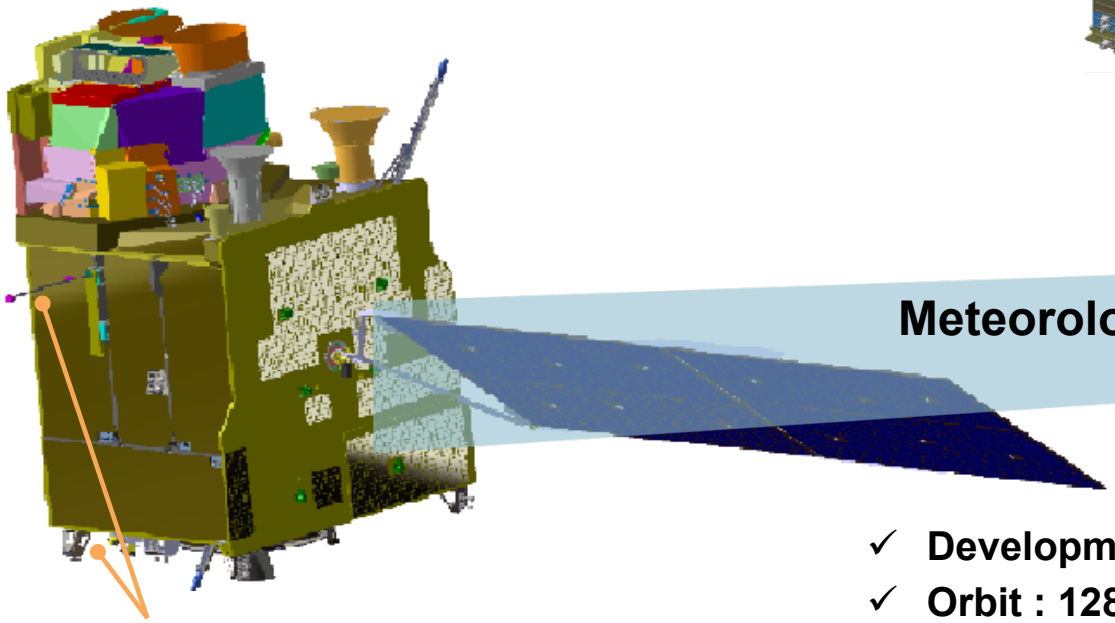
GEO-KOMPSAT-2A : Meteorological Satellite (To be launched in 2018)
GEO-KOMPSAT-2B : Ocean/Environment compound satellite
(To be launched in 2019)

KSEM accomodation on GK2A



Advanced Meteorological Imager (AMI)



Meteorology and Space Weather

Korean Space wEather Monitor(KSEM)

- ✓ **Development Period : 2012 - 2018 (7 years)**
- ✓ **Orbit : 128.2°E over equator (36,000 km)**
- ✓ **Design life : 10 years**

I KSEM Requirements and Capability

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Sensor	Parameter	Requirement	Specification
PD	Energy Range	100 keV ≤ E ≤ 2 MeV	[Electron] 80 keV ≤ E ≤ 2~3 MeV [Proton] 80 keV ≤ E ≤ ~10 MeV
	Energy Resolution	ΔE/E ≤ 30%	[Electron] 25keV@~500keV / 50keV@1MeV
			[Proton] 200keV@1MeV / 500keV@10MeV
	Time Resolution	≤ 0.33 sec	0.33 sec
	View Direction	5-direction	6-direction
	Geometric Factor	≥ 10^{-3}(cm^2·sr)	0.02 (cm^2·sr)
	Background Contamination	≤ 3%	≤ 3% for electrons ≤ 5% for protons
	Count Resolution	≥ 8 bit	8 bit
MG	Range	-350 nT ~ +350 nT (3-Axis)	Variable up to +/- 64,000 nT
	Accuracy	≤ 1nT	1nT (after ground process)
	Time Resolution	≤ 0.1 sec	0.1 s
	Type	Non-deployable	Deployable
CM	Range	-3 pA/cm^2 to +3 pA/cm^2	-3 pA/cm^2 to +3 pA/cm^2
	Accuracy	≤ 0.01 pA/cm^2	0.0015 pA/cm^2
	Time Resolution	≤ 1 sec	1 sec

I KSEM Ground Segment

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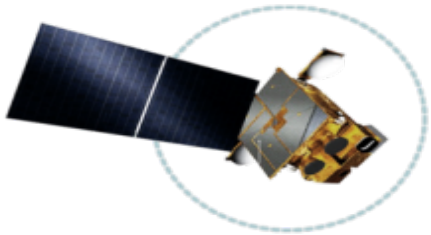

Geo-KOPMSAT-2A → KSEM

NMSC/KMA Ground Segment → Geo-KOMPSAT-2A Ground Segment

(FTP, Web)

Data Receiving and Pre-processing → LV1 → Data Processing system → LV2 → Data Analysis system → Public service

LV1 : Reconstructed, Processed instrument data at full resolution, time-referenced annotated with ancillary information including calibration coefficients and geo-referencing parameters applied

LV2 : Product retrieved using additional algorithm or model with LV1 data

I KSEM Level 1 & 2 Data Service

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Level 1 : dissemination to the end user within **5 min.** after measurement

Observation(Level 1) requiring space monitoring		
PD : High energy particle flux	**SOSMAG**: Magnetic field in 3 axes(x, y, z)	**CM :** Satellite internal charging

Level 2 : dissemination to the end user within **30 min**. after **Level 1**

Products (Level 2) requiring space monitoring (with 24hrs leading time)				
MPE (Magnetospheric Particle Environment)	**GEP** (GK2A Electron flux Prediction)	**SC** (Satellite Charging monitor)	**DIP** (Dst Index Prediction)	**KIP** (Kp Index Prediction)

II KSEM L2 Algorithm Architecture

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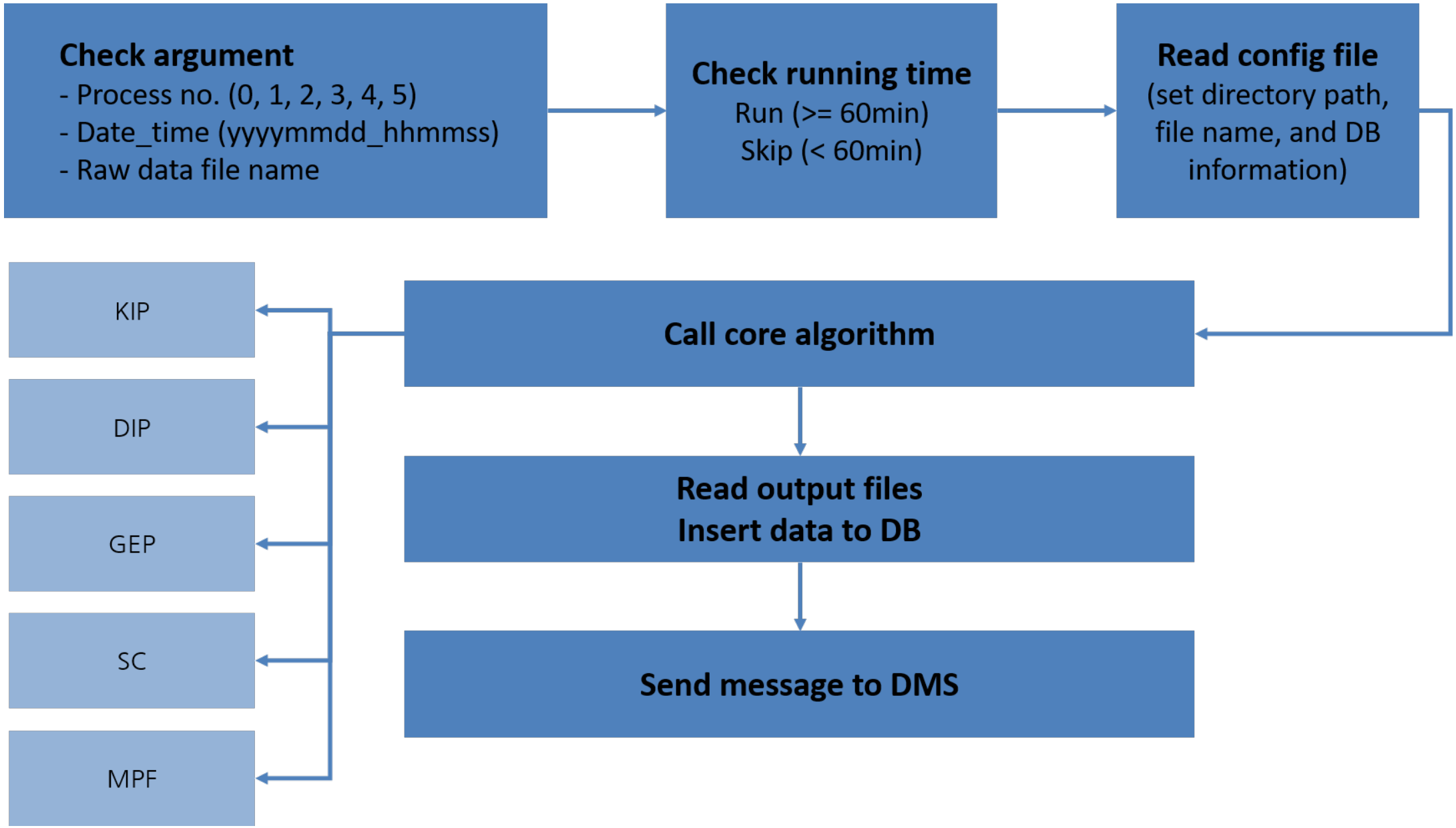
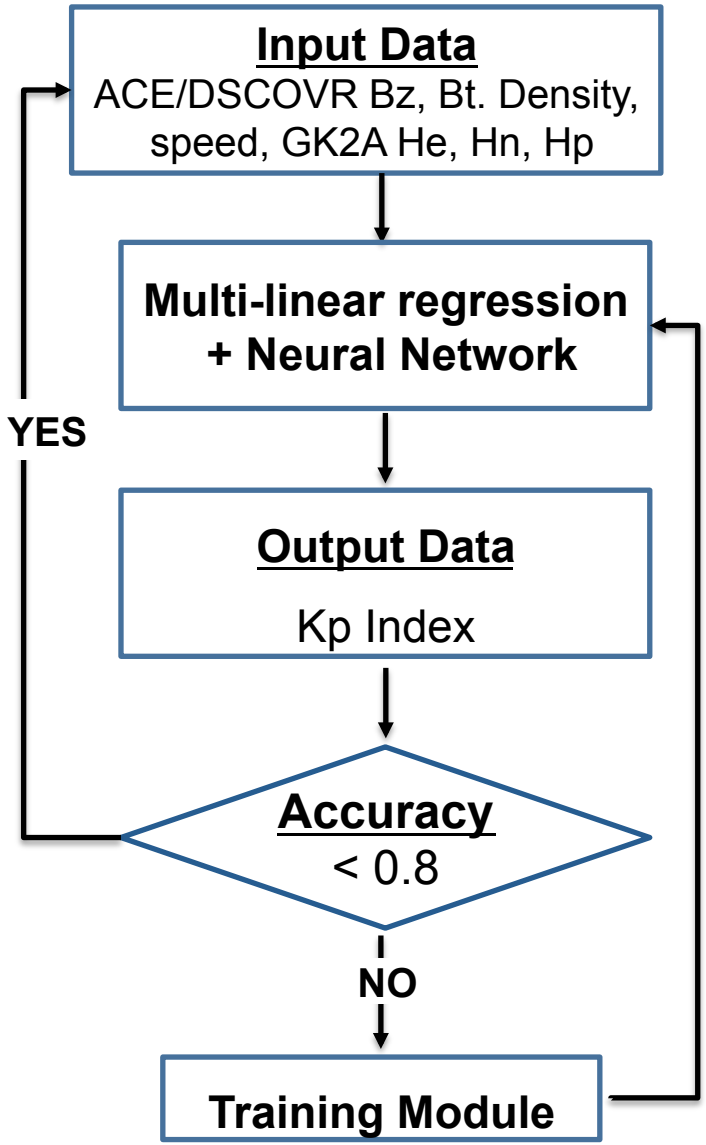


II [KIP] Prediction of Kp Index (1/2)

- **Product Description**
  - Kp index prediction with 24 hrs leading time

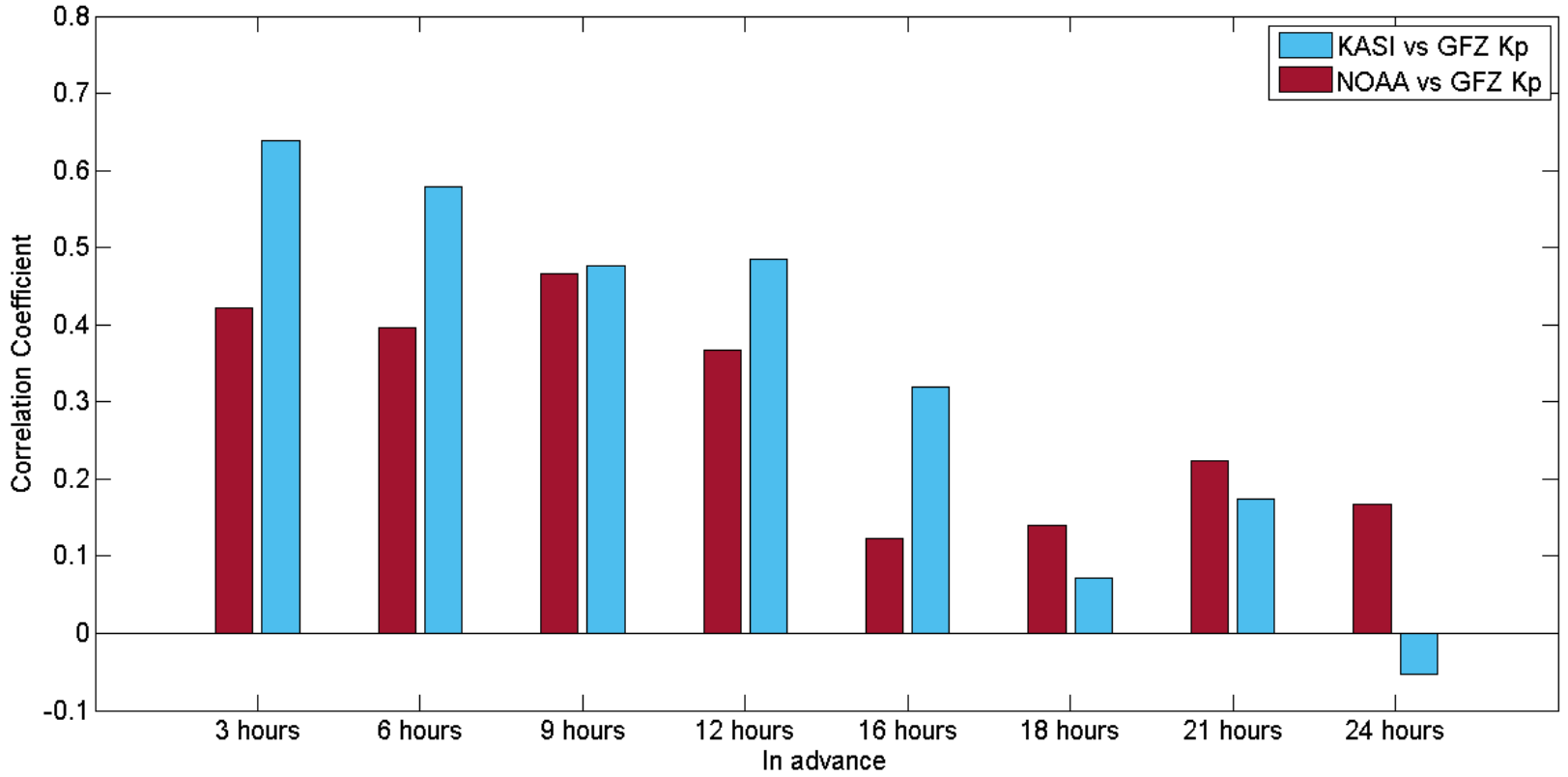
- **Algorithm Description**
  - Multi-linear regression + Neural network
    - **Multi-linear regression** made for solar wind data (speed, density and interplanetary magnetic field with 3 component of geomagnetic field)
    - **Artificial Neural Network (ANN)** for predicted Kp index using prediction results using multi-linear regression and solar wind data as the input data

[Flow Chart of Hybrid Algorithm]



[KIP] Prediction of Dst Index (2/2)

- **Test Result**
  - For Algorithm validation, correlation coefficients between prediction and measurements are calculated for three months, from May 12 to July 15, 2017.
  - The results are compared with NOAA predictions.
  - The new model shows better prediction accuracy.



II [DIP] Prediction of Dst Index (1/2)

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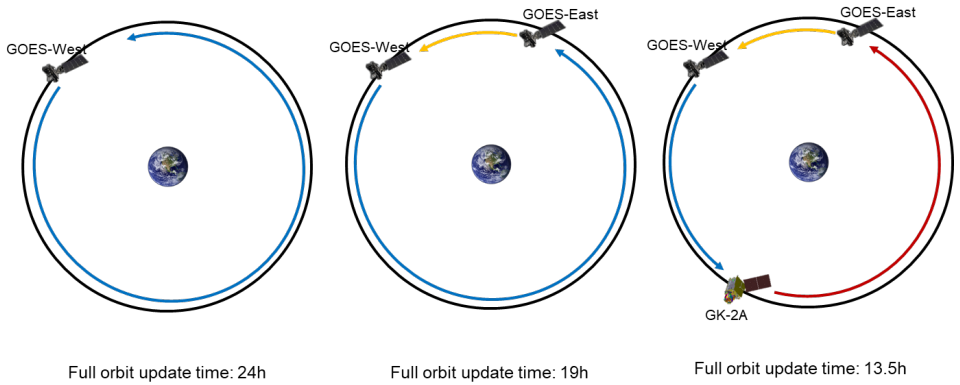
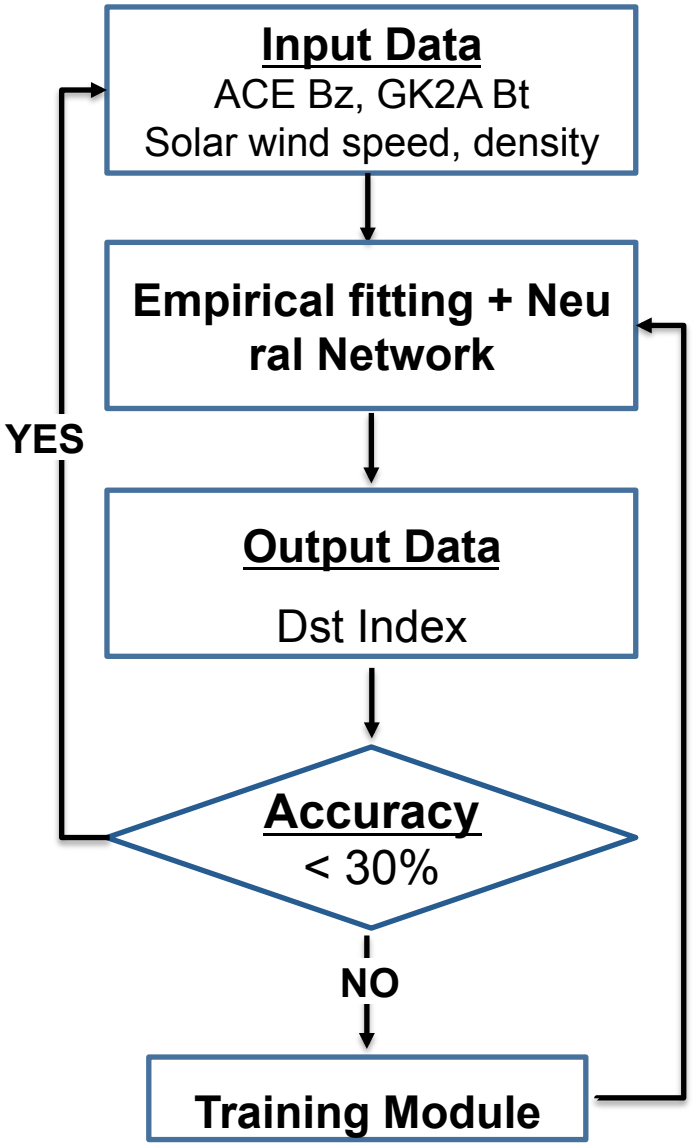
- **Product Description**
  - Dst index prediction with 24 hours leading time
- **Algorithm Description**
  - Empirical fitting + Neural network
    - **Empirical fitting** makes rough prediction from solar wind conditions
    - **Artificial Neural Network (ANN)** for predicting Dst index by using the empirical fitting, solar wind data and GEO magnetic field data.
      - ✓ This algorithm adopts multi-point magnetic field data to improve prediction accuracy.

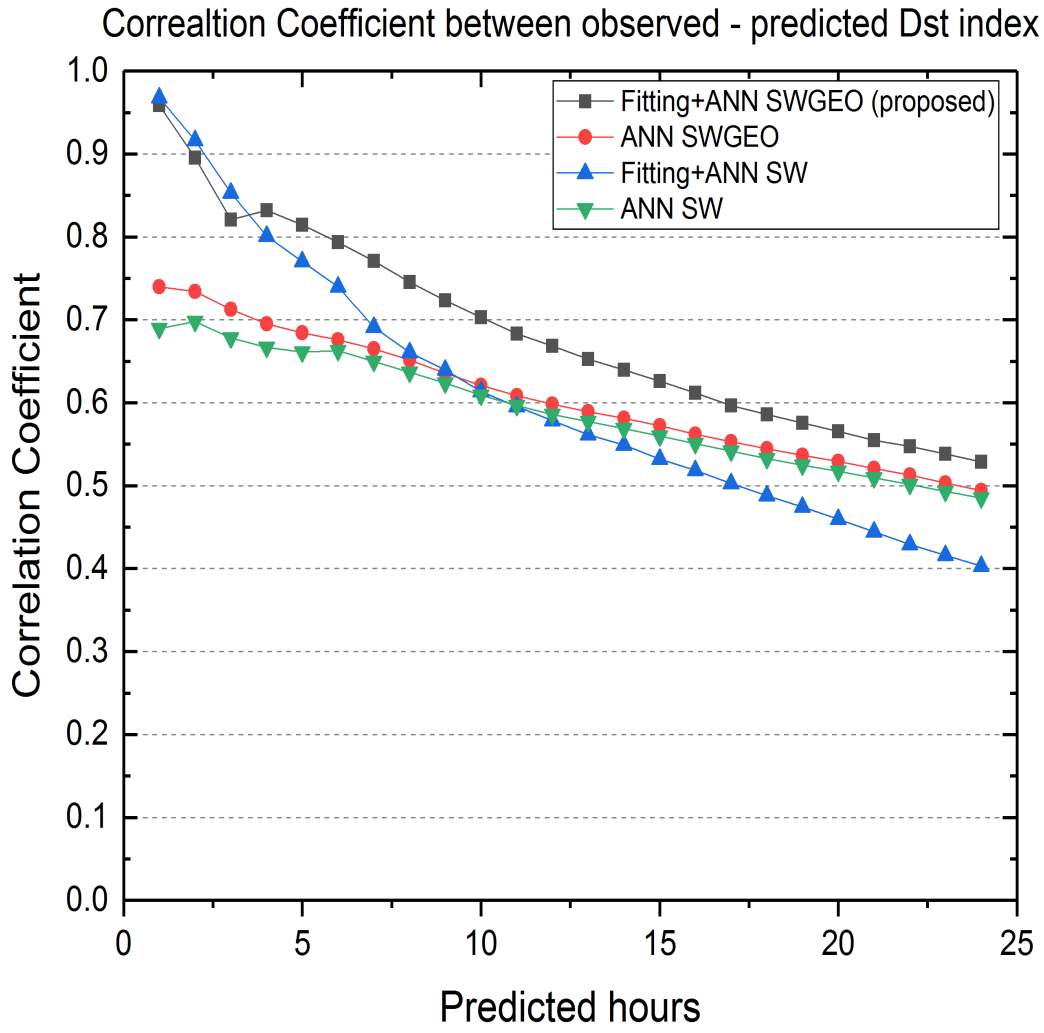


[Flow Chart of Algorithm]



[DIP] Prediction of Dst Index (2/2)

- **Test Result**
  - Test data from 2008 to 2015 used for performance validation of algorithms
  - 4 algorithms were tested ;
    - **Fitting+ANN SWGEO** (Empirical fitting + artificial neural network with solar wind and geosynchronous data) Black
    - **ANN SWGEO** (Artificial neural network with solar wind and geosynchronous data) Red
    - **Fitting+ANN SW** (Empirical fitting+artitiicial neural network with solar wind data) Blue
    - **ANN SW** (Artificial neural network with solar wind data) Green



[GEP] GK2A Electron flux Prediction (1/2)

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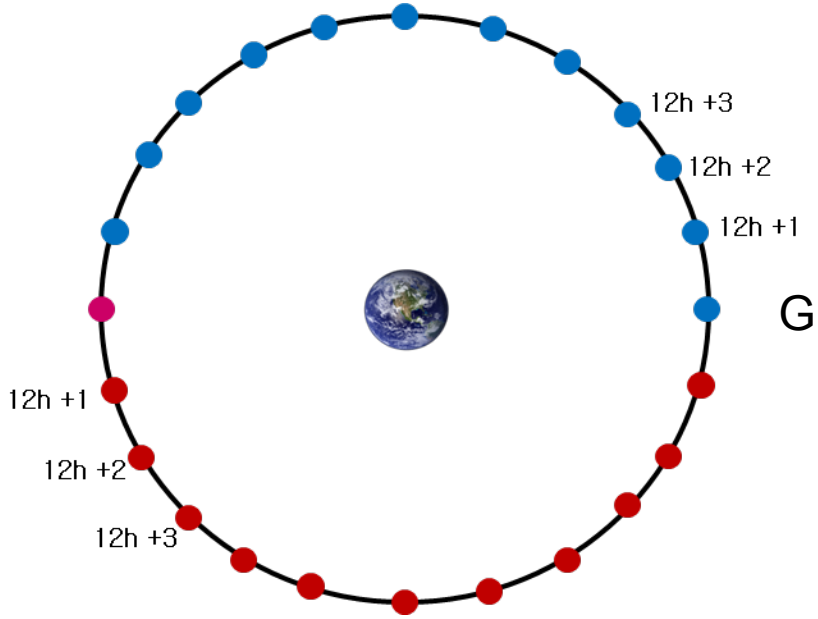
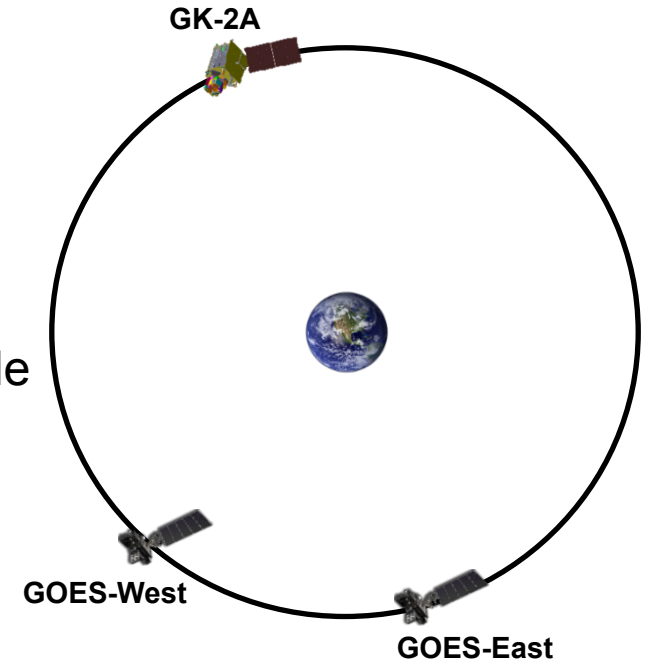
- **Product Description**
  - Prediction of Electron flux for targeted geo-satellite with 24 hours leading time.
    (GK2A, FY-4 series, Himawari-series, GOES-series, MTG series)

- **Algorithm Description**
  - **Neural network + multiple regression** with solar wind data from DSCOVR and geomagnetic index as input parameters and also using the data in combination **with GK-2A KSEM and NOAA GOES electron flux**.

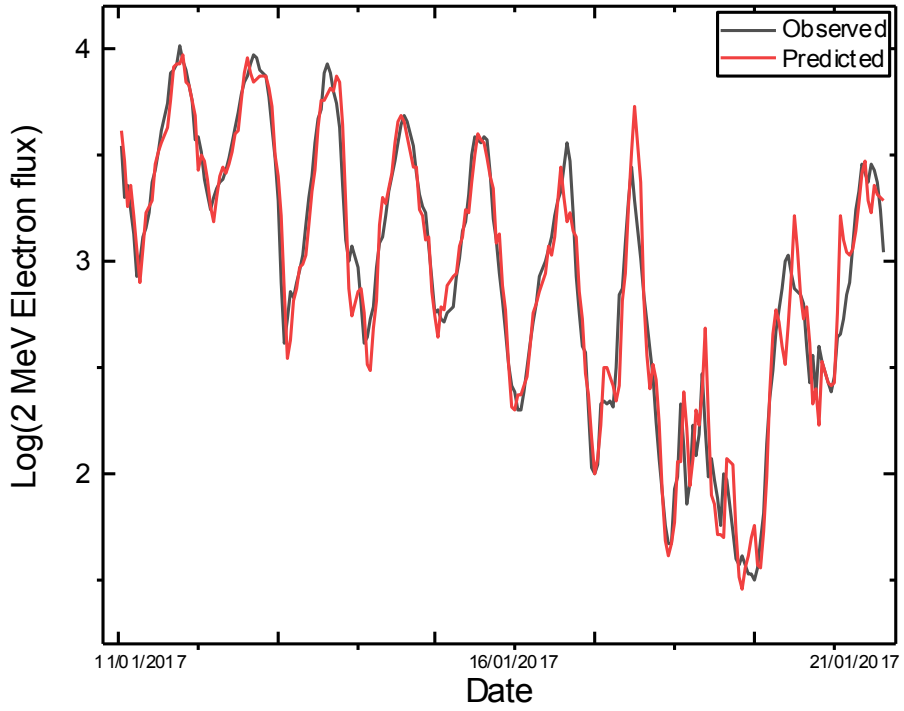


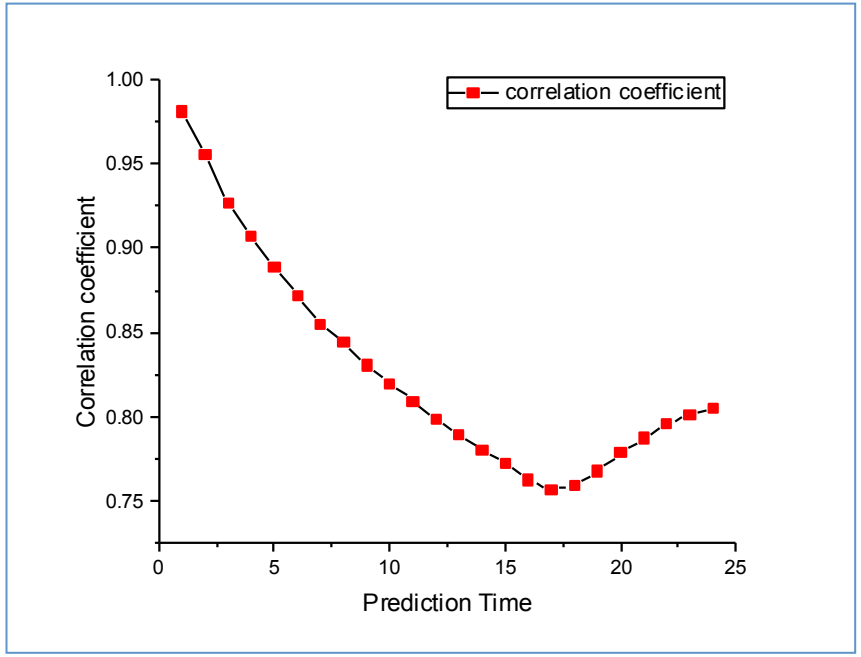
GK-2A locates almost opposite side of GOES-east



[GEP] Prediction of Electron Flux (2/2)

- **Test Result**
  - While old neural network adopts time-sequential input data from single satellite, new algorithm uses multipoint observation data as an input data.
  - (Left panel) The prediction result with 1 hour leading time.
  - (Right panel) correlation coefficient (y-axis) with the leading time(x-axis)





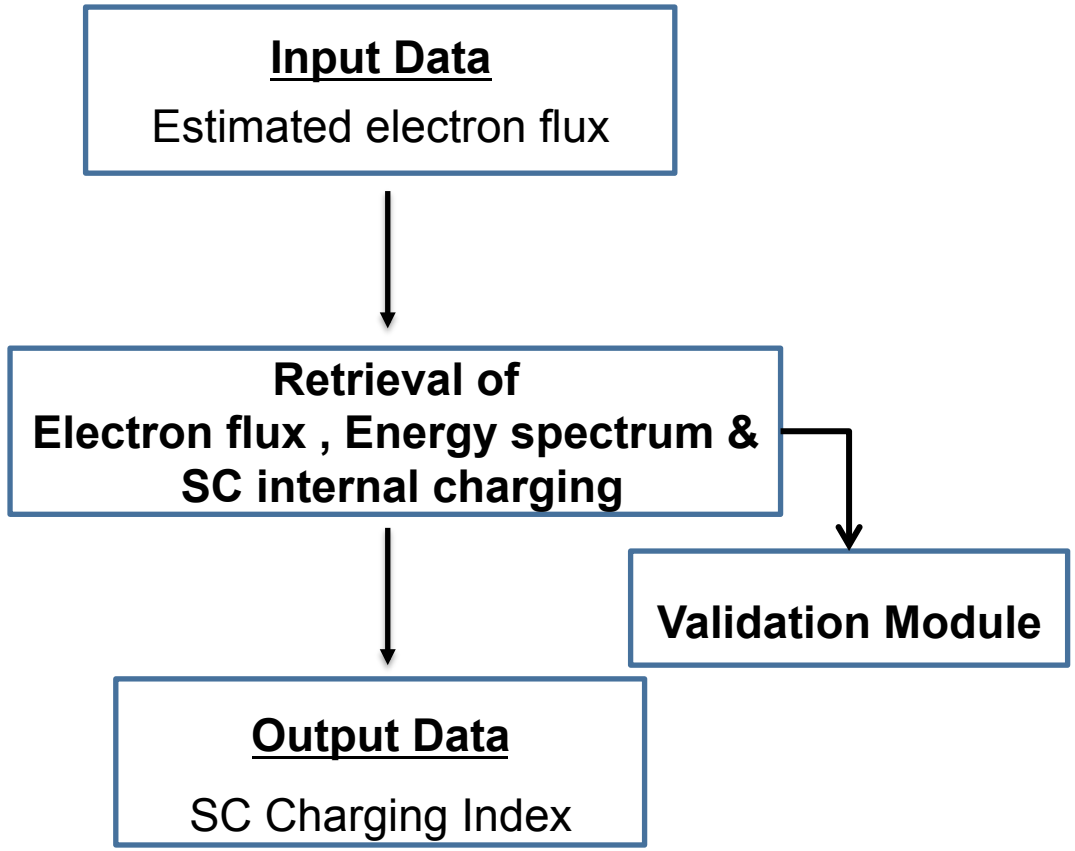
II [SC] Satellite Charging Index (1/2)

- **Product Description**
  - Satellite charging index (internal current) with 24 hours leading time
- **Algorithm Description**
  - The current(J) produced by the particles is calculated using the equation of

$$J = 2\pi \times F \times \Delta E \times P$$

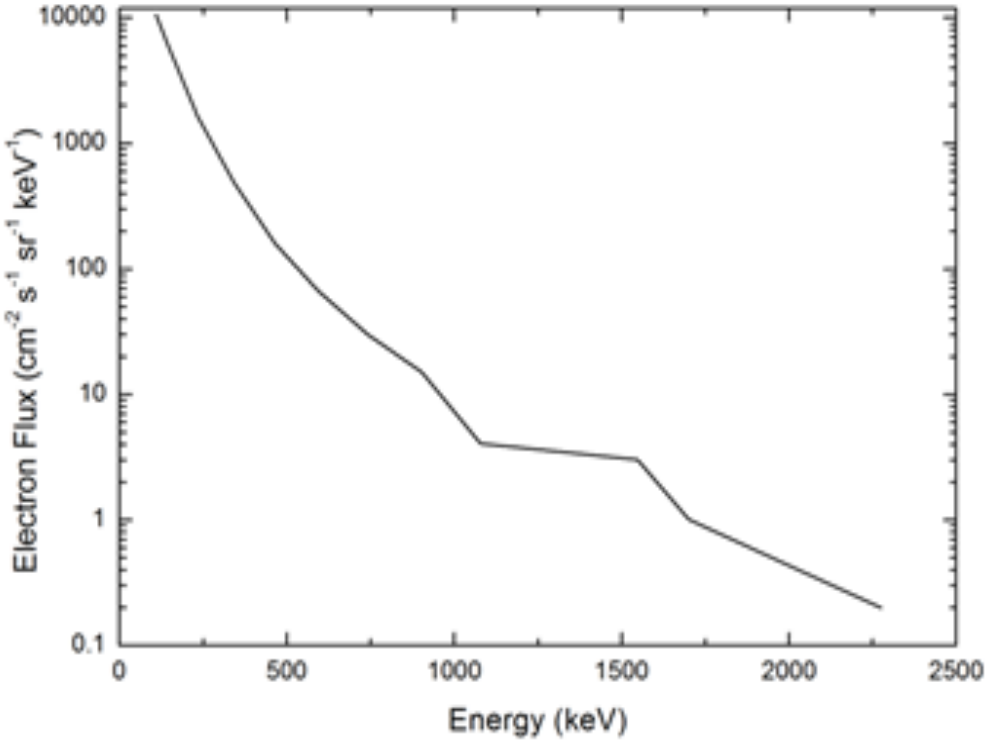
where F : particle's differential flux, E : Energy,
P: the percentage of particles penetrating the wall

[Flow Chart of Algorithm]

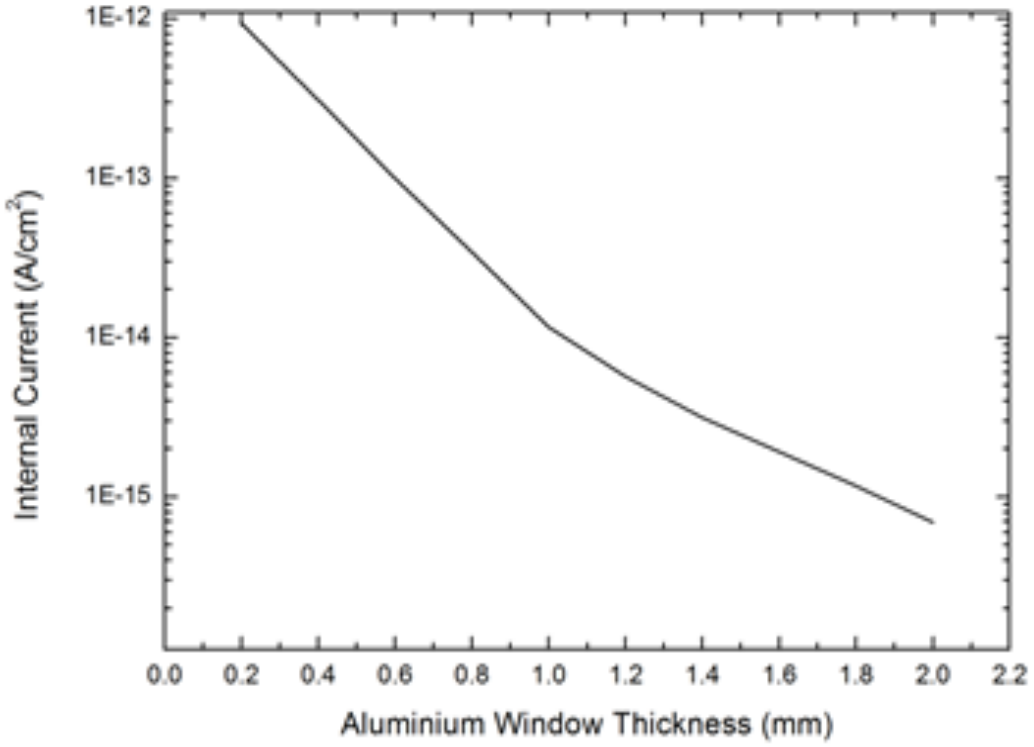


[SC] Satellite Charging Index (2/2)

- **Test Result**
  - Proxy data set is developed using VAP particle data measured at apogee (~30,000km comparable to the geostationary orbit) for algorithm test (Left panel below).
  - Internal current with respect to the aluminum thickness is estimated (Right panel below).



[Electron flux measured by VAP mission at 30,000km altitude]



[Internal current with respect to the aluminum thickness]

II [MPF] Magnetospheric Electron Flux (1/2)

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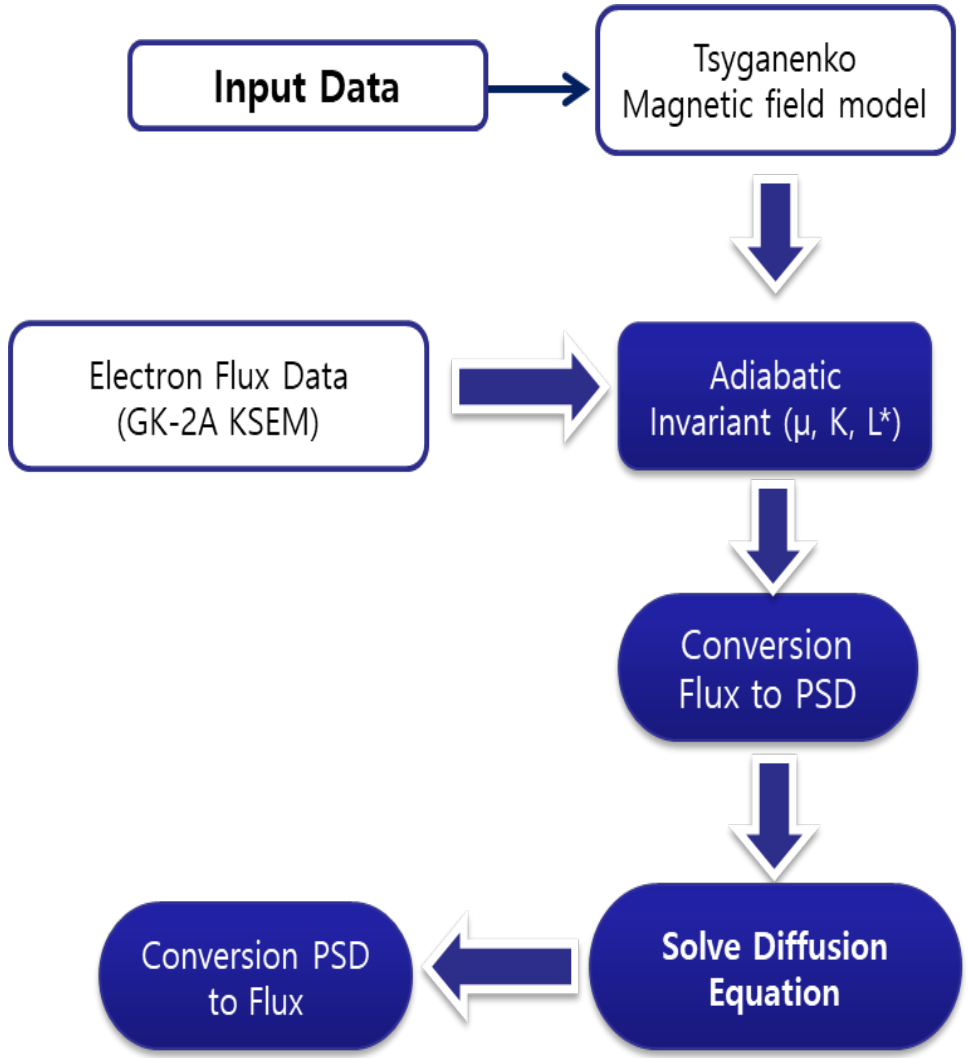
- **Product Description**
  - Real-time electron flux distribution **over whole magnetosphere**(lat, lon, L=2-7) with energy range of a few keV- dozens of MeV.

- **Algorithm Description**
  - Real-time particle distribution over magnetosphere retrieved by **solving 1-D Fokker-Plank Diffusion**

$$\frac{\partial f}{\partial t} = L^{*2} \frac{\partial}{\partial L^*}\left(\frac{D_{L^*L^*}}{L^{*2}} \frac{\partial f}{\partial L^*}\right) - \frac{f}{\tau_{L^*}} + S(L^*, t)$$

[Flow Chart of Algorithm]



[MPF] Magnetospheric Electron Flux (2/2)

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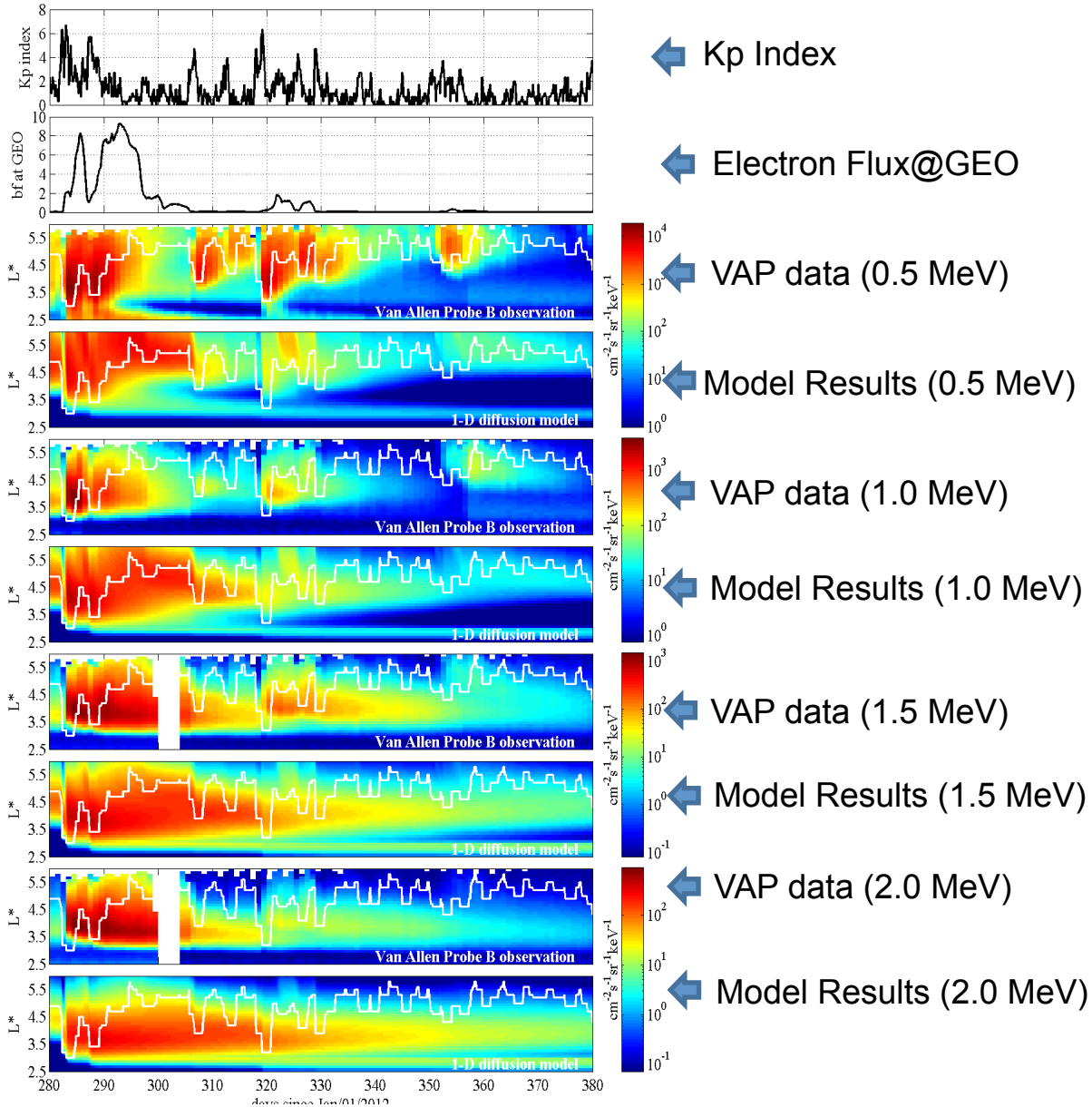
- **Test Result**
  - (Upper two panels)
    Time evolution of Kp index and GOES electron fluxes for 100 days since Jan. 01. 2012
  - (Lower eight panels)
    Comparison made between fluxes from algorithms with L and energy channels and Van Allen Probes observations(white line)



Evaluation Plan

- **Current Status**
  - L2 products developed by KASI (PM : Dr. J. Lee)
  - The project is in final phase of algorithm and proto type of codes in test phase
- **Evaluation**
  - Collaboration with peer review team for transition of KSEM's L2 products model to operation
- **Goals**
  - To secure the performance and operability of five L2 products developed as part of KSEM projects
    - ✓ Real-time Electron flux over whole-magnetosphere from L=2 to 7
    - ✓ 24hr prediction of Electron flux for the targeted satellite orbit
    - ✓ 24hr prediction of Dst
    - ✓ 24hr prediction of Kp
    - ✓ Satellite Charging Index

III Evaluation Plan

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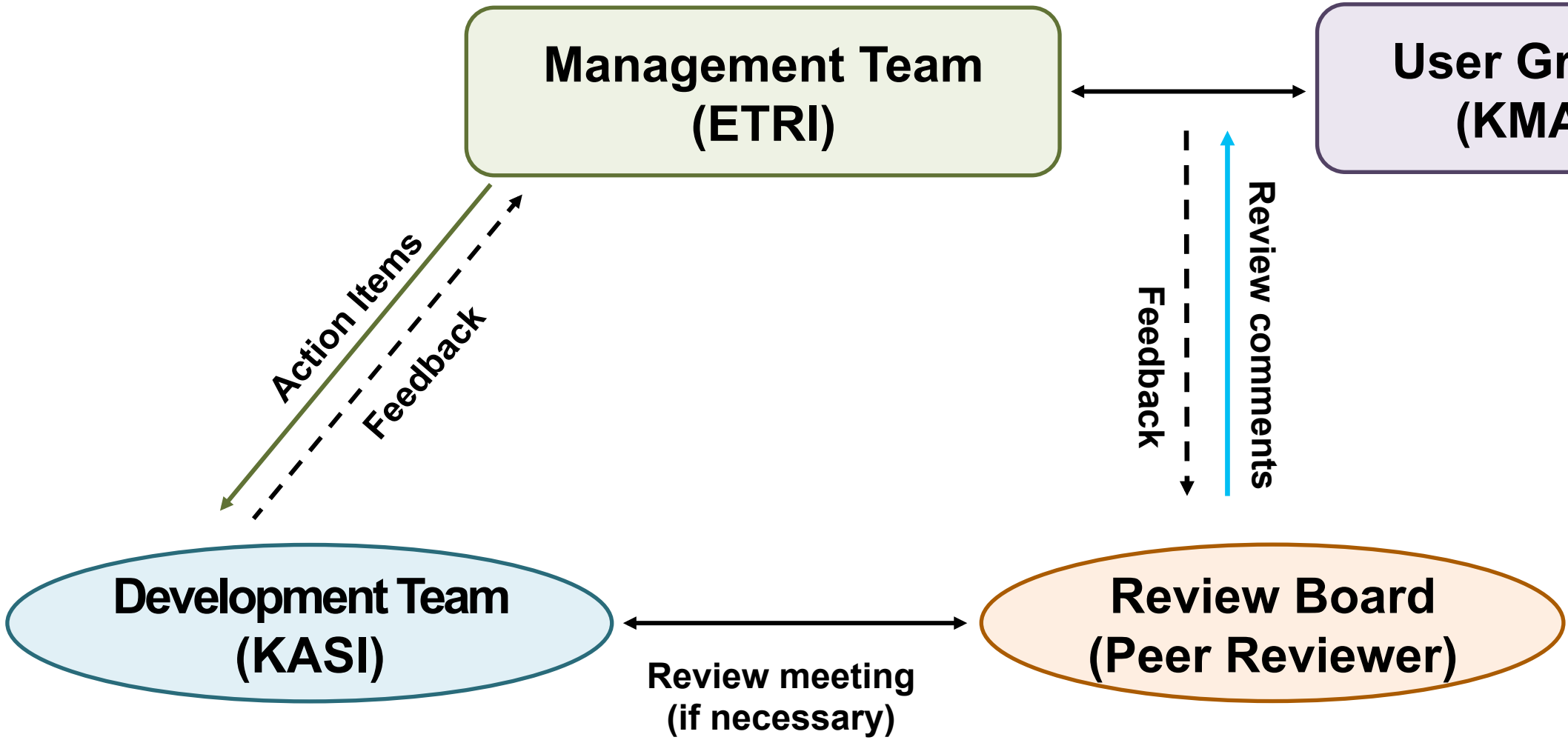

KMA : Korea Meteorological Administration
ETRI : Electronics and Telecommunications Research Institute
KASI : Korea Astronomy and Space Science Institute

III Evaluation Plan(TBC)

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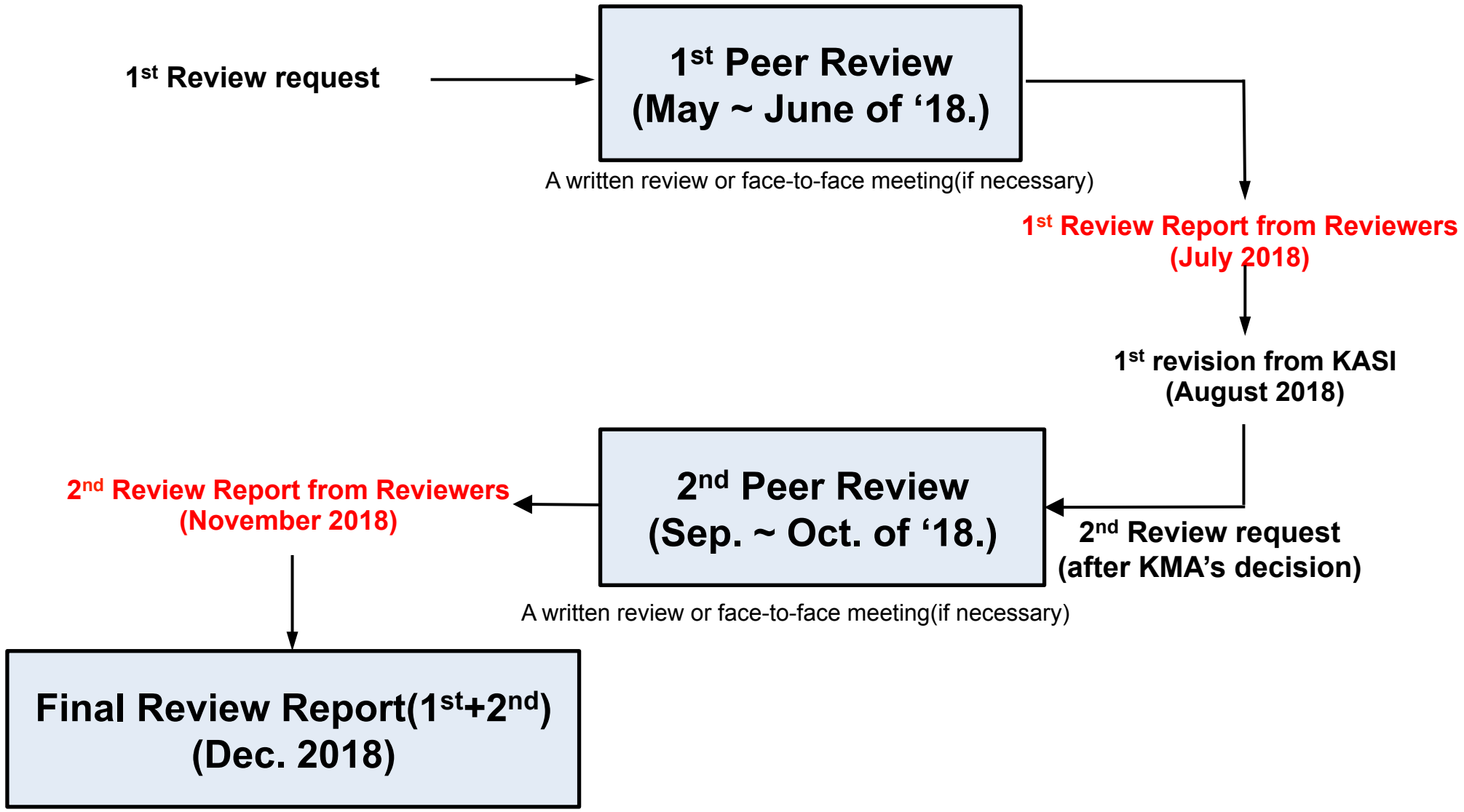

Thank You